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Impact of aerobic training on plasma leptin and pulmonary functions in obese adolescents

Aerobic training on plasma leptin and pulmonary functions

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Abstract

Aim: The present study aimed to detect and relate alteration in reaction of plasma leptin and pulmonary functions (forced vital capacity "FVC" and forced expiratory volume in the first second "FEV1") in obese adolescent schoolboys and schoolgirls to aerobic training. Material and Method: Sixty obese secondary school students with body mass index (BMI) of 30 kg/m2 or greater, with age range of 15 to 18 years participated in this study. Participants were allocated into two equal groups based on their gender: 30 schoolgirls (Group A) and 30 schoolboys (Group B). All subjects in both groups practiced moderate-intensity aerobic training program using a stationary cycle ergometer for a period of 4 months 5 days a week. Plasma leptin levels and pulmonary functions (FVC and FEV1) were measured in all students' before and after the program started. Participants were chosen from thirteen Secondary Schools, Jeddah, Saudi Arabia. They received training program at Pediatric Out-Patient Clinic, King Abdul-Aziz Hospitals. The study was conducted between June 2015 and May 2016. Results: After 4 months of aerobic exercise program, there was a significant decrease ($p < 0.05$) in leptin and significant improvement in pulmonary functions in both groups. Moreover, there was a significant difference ($p < 0.05$) in both groups in leptin levels with favor to girls group. In contrast, there was a significant difference ($p<0.05$) in both groups in pulmonary functions with favor to boys group. Discussion: Following aerobic exercise program, pulmonary functions were improved in obese adolescent schoolboys more than in obese adolescent schoolgirls. In contrast, serum leptin hormone values were improved in obese adolescent schoolgirls more than in schoolboys.

Keywords

Leptin; Ventilatory Reactions; Obese Adolescents; Aerobic Exercises.

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Introduction

Obesity incidence and its correlation with known comorbidities is extremely increased universally, in children, adolescents and in adults. Difference in its prevalence in different populations is moreover linked to certain environmental influences, exclusively diet and sedentary lifestyle. Recently, obesity and overweight have turned into one of the utmost passing-related problems worldwide due to increased processed food ingesting and reduced physical activity linked to urbanization [1]. Youthful obesity is truly a stressful general health problem. According to the International Obesity Task Force 2000, around 10% of teens between 5-17 years were overweight, amid which 2-3% was obese. It is estimated at 30-45 million obese children and 155 million overweight universally [2]. The increasing adolescent obesity is of major significance, as it is a general health epidemic which manifested in fetal deaths, a lot of morbid debilities and higher medical care expenses [3]. It is of superior significance as it accompanies risky health problems, as coronary artery disease, high plasma lipids, chronic pulmonary problems, sleep apnea and type 2 diabetes [4]. Overweight in children, adolescents and adults is basically due to extra calories intake matched to caloric expenditure. Features related to genetics, environment, socio-cultural state and family are recognized as main stimuli on food consumption and caloric expenditure that consequently lead to overweight [5].

The serum leptin level is high in plasma of obese persons more than of thin. Naturally, leptin acts via reducing the appetite and rising caloric expends [6]. Blood leptin level has direct relation with the amount of the body fat and other determinants of obesity as BMI. Greater leptin levels are found in girls than in boys [7]. While it is estimated that higher leptin levels could lessen energy consumption in obese children, in fact, energy consumption in obese children is greater than that in slim children, this is termed leptin resistance [8].

Likewise, it is known that respiratory problems are more common in obese children, and the declined static lung volumes were considerably interrelated with obesity grade [9]. Teen-ager as adult obesity affects pulmonary functions during rest and throughout exertion. Obesity rises airway hyper-responsiveness (AHR), declines peak expiratory flow (PEF), forced vital capacity (FVC), and forced expiratory volume (FEV1) [10]. Obesity causes many harmful effects on pulmonary functions. Respiratory and skeletal muscles strength, endurance, gaseous exchange, and respiratory control are all declined and interrupted in obese children.

Obesity similarly restricts lung function testing and exercise capacities [11]. Pulmonary mechanics changes triggered by obesity might be caused by possible lung restrictions [12].

Body activity is essential in controlling childhood obesity and must be adapted separately according to obesity level, age, and existence of complications. Body activity raises energy expenses and fat reduction, guards against lean body mass loss, develops cardiopulmonary endurance, lessens obesity-associated cardio-metabolic health threats, and induces well-being sense [14]. Plasma leptin can be assumed to be fat tissue besides motion reliant. Plasma leptin is adversely linked with respiratory markers (FEV) and bodily movement in obese adolescents [14]. Plasma leptin level decline with exercising and rise with a lack of aerobic exercise in obese adolescents, with a superior decline in children with higher pre-exercise levels [15]. Adolescent obesity reduces FVC and FEV1. Proper aerobic training raises FVC and FEV1 in obese students and improves respiratory muscle function [16].

No investigator clarified the correlation of adiposity in both sixes to plasma leptin levels and responses to exercises [5]. Some studies clarified the impact of training on obesity correlated alterations in obese children, but then until now, no research clarified or compared gender responses of leptin and pulmonary reactions to training in obese children definitely. Therefore, the aim of this investigation was to define and narrate sex-correlated reaction of plasma leptin and lung functions with aerobic exercise in both obese sexes.

Material and Method

The study was designed as a prospective, pre–and post-tests. Ethical approval was obtained from the institutional review board at King Abdul Aziz University Hospitals. The study was following the Guidelines of the Declaration of Helsinki on the conduct of human research. The study was conducted between June 2016 and May 2017.

Convenient samples of sixty obese secondary school students were recruited from thirteen Secondary Schools, Jeddah, Saudi Arabia. They were enrolled and assessed for their eligibility to participate in the study. The participants with (BMI ≥ 30 kg/m^2), normotensive, non-diabetic, non-asthmatic secondary school, students aged between 15-18 years were chosen to be included in the study. The participants who had major medical conditions or medication that might alter the study results, or lead to harmless contribution were excluded from the study

Informed consent was obtained from each participant or their parents after explaining the nature, purpose, and benefits of the study, informing them of their right to refuse or withdraw at any time, and about the confidentiality of any obtained information. Participants were allocated along with sex into two equal groups: 30 obese adolescent schoolboys (Group A) and 30 obese adolescent girls (Group B). No subjects dropped out of the study after allocation.

Participants allocated into group A consisted of 30 adolescent schoolboys. Group B consisted of 30 obese adolescent girls. Both groups completed aerobic training with a stationary bicycle five days a week with no extra diet supply, extra calories or diets during the experiment. Participants were tutored to keep the same level of exertion through the non-exercise times. Every adolescent in group A and B experienced 16 weeks five times a week of directed aerobic training of moderate intensity using a fixed cycle (Universal aero cycle, USA). Starting with warming up (5-10 minutes) by cycling at low speed with no resistance. Active stage involved a gradual increasing duration from 20-40 minutes along with participant tolerance and progressively rising exercise intensity from 50-70 % of HRmax attained after the increasing symptom-limited workout testing for every applicant. Cool downstage was about 5-10 minutes free cycling with lower speed with no resistance [17].

Investigation variables were plasma leptin, FEV1, and FVC [18]. Regular aerobic physical activity decreases the risk of coronary heart disease by improving the plasma leptin levels and thus aerobic activity can be used as an effective non-pharmacological management for obesity [19,20]. Examination was done before and after the four months training program for all adolescents at pediatric out-patient clinic of King Abdul-Aziz Hospitals.

Pulmonary functions (FVC and FEV1) were assessed by three trials in order to obtain the best values. The measurements were done by an Easy-One 2001 spirometer (ndd Medical Technologies, Z¨urich, Switzerland). The values were expressed in absolute terms and as a percentage of the theoretical value for those of the same age, weight, and height in the reference population [21].

Plasma leptin hormone levels were measured with Enzyme-Linked Immune Sorbent Assay (ELISA) technique using ELISA EIA-2395 kit, Germany. Before and after the study, blood sample (3 ml.) was withdrawn from each participant in a sterile tube inclosing K2EDTA, afterward was centrifuged in order to separate plasma and kept freezing at - 20°C until analysis was finished [18].

Body mass of each participant was measured wearing very light clothing to the nearest 0.1 kg and height was assessed barefoot to the nearest 0.1 cm using a well calibrated medical weight scale and stadiometer tools, considering BMI as weight (kg) / height squared (m2). Adolescent obesity was considered with BMI equivalent to or greater than the 95th percentile of BMI used for both age and sex [2]. An increasing symptom-restricted aerobic exercise testing on a calibrated electronic cycle ergometer was completed for every applicant based on the standard recommended values to classify maximum heart rate (HR max) for detecting training intensity for every adolescent [22,23].

Statistical analysis

All statistical measures were performed using the Statistical Package for Social Science (SPSS) program version 22 for windows. Prior to final analysis, data were screened for normality assumption and presence of extreme scores. This exploration was done as a pre-requisite for parametric calculation of the analysis of difference and analysis of related measures. Descriptive analysis using histograms with the normal distribution curve showed that the data were normally distributed and didn't violate the parametric assumption for the leptin, FVC, FEV1, and BMI. Additionally, testing for the homogeneity of covariance using Box's test revealed that there was no significant difference with p values of > 0.05. Normality test of data was performed using the Shapiro-Wilk test that reflects the data was normally distributed for the leptin, FVC, FEV1, and BMI. All these findings allowed the researchers to conduct parametric analysis. So, Comparison of different variables within and between groups was performed using paired and unpaired t-test. The alpha level was set at 0.05.

Results

Sixty obese adolescents (30 boys and 30 girls) started the 16-week aerobic exercise program and experienced final investigation after a 4-months period. There were no statistically significant differences (P > 0.05) between subjects in both groups concerning age, weight, and height (Table 1).

Table 2 presents descriptive statistic (mean ± SD) for all dependent variables between both groups. Results for leptin within groups showed that "Paired t-test" revealed a significant reduction of leptin (p < 0.05) for both groups. In results between groups, "unpaired t-test" revealed that the mean values of the "post" test between both groups showed there were significant differences (p<0.05) and this significant reduction in favor of group A. Concerning FVC and FEV1 within groups, "Paired t-test" revealed that there was a significant increase in FVC and FEV1 (p < 0.05) for both groups. As for results between groups, "unpaired t-test" revealed that the mean values of the "post" test between both groups showed there were significant differences (p<0.05) and this significant increase in favor of group B. Regarding to BMI results within groups, "Paired t-test" revealed that there was a significant reduction of BMI (p < 0.05) for both groups. As for results between groups, "unpaired t-test" revealed that the mean values the "post" test between both groups showed there were significant differences (p<0.05) and this significant reduction in favor of group B (Table 3).

Table 1. Physical (general) characteristics of the two studied groups.

Variables	Group (A) (n= 30)	Group (B) (n= 30)	P value
Age (yrs.)	16.8 ± 0.82	17.1 ± 0.5	0.55
Weight (Kg.)	75 ± 7.48	75 ± 7.75	0.975
Height (cm.)	154.27 ± 9.09	151.32 10.6	0.445

*significant (p < 0.05).

Table 2. Descriptive statistics for the all dependent variables for both groups at different training periods.

Group B		Group A		
Post	Pre	Post	Pre	Variables
16.95 ± 2.75	18.72 ± 3.23	13.89 ± 0.12	17.6 ± 2.68	Leptin (ng/ml)
2.7 ± 0.92	1.99 ± 0.03	2.28 ± 0.59	2.15 ± 0.35	FVC (L)
2.3 ± 0.14	1.79 ± 0.67	1.98 ± 0.14	1.74 ± 0.22	FEV1 (L)
25.26 ± 0.84	32.7 ± 0.87	26.1 ± 1.14	31.51 ± 1.13	BMI (kg/m²)

Values of all dependent variables are expressed as mean ± SD.

Table 3. Multiple pairwise comparison tests (Post hoc tests) for the all dependent variables at both groups.

Within groups (Pre Vs. Post)				
p-value	Leptin	FVC	FEV1	BMI
Group A	0.0001*	0.02*	0.01*	0.0001*
Group B	0.002*	0.0001*	0.0001	0.0001*
Between groups (Study Vs. Control)				
p-value	Leptin	FVC	FEV1	BMI
Pre treatment	0.073	0.101	0.265	0.095
Post treatment	0.002*	0.03*	0.002*	0.01*

*Significant at the alpha level (p < 0.05)

Discussion

The outcomes of the current trial revealed a significant decline in BMI in the two groups, in favor of the girls group. This result was in accordance with another study that investigated the effects of both aerobic and anaerobic exercise in obese persons and mentioned that aerobic exercise resulted in a significant decline in BMI, which was greater than the produced by anaerobic exercise training [24]. A study of the impact of 4 months with low-calorie diet in association with aerobic training to a low-calorie diet alone in obese children 4–16 years of age, found similar findings. Aerobic exercise showed a significantly greater decline in overweight percentage than in the group treated by diet only [25]. These results were granted with a study for 4-month of 40-minute aerobic training, 5 days a week, led to a substantial decline in participants' body fat levels in obese 7-11-year-old children matched with other obese controls [15]. Likewise, activity only might have a significant advantage for overweight and obese children. It had been stated that steady and continuing aerobic training for three months had an optimistic influence on obese girls BMI [26].

The current study outcomes verified that aerobic exercising decreases leptin levels in obese adolescents and that plasma leptin reacts extra positively in obese adolescent girls more than in boys. The outcomes about leptin hormone response to aerobic training agree with weight reduction studies in children, displaying that serum leptin levels in obese children declined with exercise work out and that superior decrease was noted in children with greater pre-treatment leptin values [27].

Serum leptin value is not only raised in obese schoolgirls in comparison with obese boys, but it seems like it is as well high in healthy schoolgirls matched with healthy schoolboys. In a study of healthy children, sex variances in serum leptin relative to daily bodily motion established this outcome [28]. Serum leptin reaction to aerobic exercises in obese children can be understood based on resultant significant physiological variations and alterations in the levels of specific hormones that can change leptin levels, as insulin, cortisol, estrogen, catecholamines, testosterone, and growth hormones [28]. Aerobic exercise training-resulting reduction in serum leptin might be due to altered glucose-regulations; as improved in insulin sensitivity and lipid metabolism [19]. Moreover, decreased leptin levels in obese children following aerobic exercises may be caused by variations of energy balance system [27]. Serum leptin levels drop 48 hours next to prolonged aerobic training suggesting a late drop in leptin, which might be produced by energy imbalance state [24]. The drop of serum leptin might be accompanied by overproduction of non-esterified fatty acids throughout exercises that is inversely related to serum leptin levels [31].

Lung functions change greatly by obesity as well as reduction of exercise capacity via its opposing influence on pulmonary mechanisms, respiratory system resistance, respiratory muscle role, pulmonary volumes, respiratory control and gaseous interchange [30]. Researches assessing overweight influences on lung functions have created mutable findings. This could be owing to different standards for assessing obesity, number of participants, and mutable grades of obesity. In fact, in children, the effect of fat tissue and obesity level where lung function is altered are not accurately investigated [31]. Relative to values of age, sex, height, expiratory reserve volume, FEV1, FEF 25-75, maximum voluntary ventilation (MVV), absolute and corrected alveolar diffusion capacity (DLCO) were all declined in obese persons [18]. This can be caused by abnormal alveolar diffusion and structural alterations of lung interstitial tissue via deposition of lipids and/or a decrease of alveolar surface area [32].

Outcomes of the current study showed that aerobic exercise training protocol caused a significant rise in FVC and FEV1 in obese adolescents; supporting schoolboys. Greater proportions of alteration in those variables were observed in boys paralleled with girls. Aerobic exercise in children with cognitive difficulties led to better pulmonary function [30]. Findings of the current study come in agreement with a study on aerobic training; had significant influence on pulmonary function as well as tracheal indexes in overweight schoolboys. The rise in FVC following aerobic training seems to be because of improved lung volumes and elastic recoil [33]. Conversely, altered FVC was via improvement in intercostal muscles. As a result, raised respiratory muscle strength and endurance rises FVC sequentially [34].

The findings of the study may be limited by lack of previous recent studies that used aerobic exercise program for studying leptin and pulmonary functions improvement in obese adolescent cases, small sample size due to delayed administrative issues regarding school students, and

restrictions of the Saudi community to take any photos of female patients, as it was not allowed and refused also by participants, that is why we did not add any photos to the procedures.

Conclusion

According to the preceding debate and agreeing to the data linked to the current study, we can summarize that aerobic training improves plasma leptin and lung function in obese adolescents. Whereas aerobic training decreases leptin in obese adolescents, reaction of leptin levels to aerobic training in obese girls was superior to that of boys. Furthermore, while aerobic training enhanced pulmonary functions in obese adolescents, it appears obviously that lung function reactions in obese boys were better than those of girls. It is suggested to practice aerobic programs to decrease leptin level and raise lung function in obese adolescents.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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References

1. Steckling FM, Lima FD, Boufleur J, Farinha DL, Alexandre F, Soares A. Obesity, Inflammation and Aerobic Physical Exercise. Ann Sports Med Res. 2015; 2(2): 1017.

2. Cole T J, Flegal K M, Nicholls D, Jackson A A. Body mass index cut offs to de-

fine thinness in children and adolescents: international survey. Bri Med J. 2007; 335(7612): 194.
3. Gonzalez L, Gilmer L. Obesity prevention in pediatrics: A Pilot Pediatric Resident Curriculum Intervention on Nutrition. JNMA. 2006; 98 (9): 1483-8.
4. Kiess W, Galler A, Reich A, Muller G, Kapellen T, Deutscher J et al. Clinical aspects of obesity in childhood and adolescence. Obes Rev. 2001; 2(1): 29 - 36.
5. Seabra A, Katzmarzyk P, Carvalho MJ, Seabra A, Coelho-E-Silva M, Abreu S et al. Effects of 6-month soccer and traditional physical activity programmes on body composition, cardiometabolic risk factors, inflammatory, oxidative stress markers and cardiorespiratory fitness in obese boys. J Sports Sci. 2016; 34(19): 1822-9.
6. Moran O, Phillips M. Leptin, obesity, diabetes and other peripheral effects: A review. Pediatr Diabetes. 2003; 4(1): 101-9.
7. Dencker M, Thotsson O, Karlsson K, Linden C, Wollmer P, Ahren B. Leptin is closely related to body fat in pre-pubertal children aged 8-11 years. Acta Paediatrica. 2006; 95: 975-9.
8. Lahlou N, Landais P, De Boissieu D, Bougneres P-F. Circulating leptin in normal children and during the dynamic phase of juvenile obesity. Diabetes. 1997; 46: 989–93.
9. Li M, Chan D, Wong E, Yin J, Nelson A, Fok F. The effect of obesity on pulmonary function. Arch Dis Child. 2003; 88 (4): 361- 3.
10. Ulger Z, Demir E, Tanac R, Goksen D, Gulen F, Darcan S et al. The effect of childhood obesity on respiratory function tests and airway hyperresponsiveness. Turk J Pediatr. 2006; 48: 43–50.
11. Lotti P, Gigliotti F, Tesi F, Stendardi L, Grazzini M, Duranti R, Scano G. Respiratory muscles and dyspnea in obese nonsmoking subjects. Lung. 2005; 183(5): 311-23.
12. Costa D, Barbalho C, Miguel P, Forti M, Azevedo C. The impact of obesity on pulmonary function in adult women. Clin Sci J. 2008; 63(6): 719-24.
13. Hainter V, Toplak H, Mitrakou A. Treatment modalities of obesity. Diabetes Care. 2008; 31 (Suppl. 2): S269–S77.
14. Gonzalez-Barcala J, Takkouche B, Valdes L, Leis R, Alvarez-Calderon P, Cabanas R, et al. Body composition and respiratory function in healthy non-obese children. Pediatr Int. 2007; 49 (5): 553- 7.
15. García-Hermoso A, Ceballos-Ceballos R J M, Poblete-Aro C E, Hackney A C, Mota J, Ramírez-Vélez R. Exercise, adipokines and pediatric obesity: a meta-analysis of randomized controlled trials. Int J Obes. 2017; 41: 475–82. Doi:10.1038/ijo.2016.230.
16. Azad A, Gharakhanlou R, Niknam A, Ghanbari A. Effects of aerobic exercise on lung function in overweight and obese students. Tanaffos. 2011; 10(3): 24-31.
17. Kanaley JA, Heden TD, Liu Y, Whaley-Connell AT, Chockalingam A, Dellsperger KC, Fairchild TJ. Short-term aerobic exercise training increases postprandial pancreatic polypeptide but not peptide YY concentrations in obese individuals. Int J Obes (Lond) 2014; 38: 266–71.
18. García-Hermoso A, Cerrillo-Urbina A, Herrera-Valenzuela T, Cristi-Montero C, Saavedra J, Martínez-Vizcaíno V. Is high-intensity interval training more effective on improving cardiometabolic risk and aerobic capacity than other forms of exercise in overweight and obese youth? A meta-analysis. Obes Rev.2016; 17: 531–40.
19. Xiaochen L, Xi Zhang, J, Christian K, Steve M, Wen-Chih W, Simin L, et al. Effects of Exercise Training on Cardiorespiratory Fitness and Biomarkers of Cardiometabolic Health: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Am Heart Assoc. 2015; 4.Doi: 10.1161/JAHA.115.002014.
20. Akbarpour M. The Effect of Aerobic Training on Serum Adiponectin and Leptin Levels and Inflammatory Markers of Coronary Heart Disease in Obese Men. Biol. Sport. 2013; 30: 21-7.
21. Piotr Z, Krzysztof M, Ewa K, Szczypiorski P, Frysztak A. Effects of Organized Physical Activity on Selected Health Indices among Women Older than 55 Years. Sci World J. 2015; 2015:8.
22. Akalan C, Robergs RA, Kravitz L. Prediction of VO2max from an individualized submaximal cycle ergometer protocol. J Exerc Physiol Online. 2008; 11(2): 1-7.
23. Paridon M, Alpert S, Boas R, Cabrera E, Caldarera L, Daniels R, et al. Clinical stress testing in the pediatric age group: A Statement from the American Heart Association Council on Cardiovascular Disease in the Young, Committee on Atherosclerosis, Hypertension, and Obesity in Youth. Circulation. 2006; 113:1905-20.
24. Kraemer R, Chu H, Castracane D. Leptin and exercise. Exp. Biol. Med. 2002; 227:701-8.
25. Saygm O, Ozturk A. The effect of twelve-week aerobic exercise programme on health related physical fitness components and blood lipids in obese girls. AJPP. 2011; 5(12): 1441-5.
26. Gutin B, Ramsey L, Barbeau P, Cannady W, Ferguson M, Litaker M, et al. Plasma leptin concentrations in obese children: changes during 4-months periods with and without physical training. Am J Clin Nutr.1999; 69: 388–94.
27. Romon M, Lafay L, Bresson L, Oppert J-M, Borys J-M, Kettaneh A, et al. Relationships between physical activity and plasma leptin levels in healthy children: The Fleurbaix– Laventie Ville Sante II Study. Int J Obes. 2004; 28: 1227–32.
28. Kraemer R, Acevedo O, Synovitz B, Durand J, Johnson G, Petrella E, et al. Glucoregulatory endocrine responses to exercise and the role of a pancreatic ß-cell peptide amylin. Metabolism. 2002; 51: 657–63.
29. Elias N, Pandian R, Wang L, Suarez E, James N, Wilson F. Leptin and IGF-I levels in unconditioned male volunteersafter short term exercise. Psychoneuroendocrinology. 2000; 25: 453–61.
30. Jones L, Nzekwu M. The effects of body mass index on lung volumes. Chest J. 2006; 130 (3): 827-33.
31. Ergun C, Cengizlier R, Aslan T, Aycan Z, Yilmaz H, Agree C. Effect of obesity on pulmonary function in children. New J Med. 2007; 24(2): 97- 9.
32. Vasconcellos F, Seabra A, Cunha F, Montenegro R, Penha J, Bouskela E, et al. Health markers in obese adolescents improved by a 12-week recreational soccer program: a randomised controlled trial. J Sports Sci. 2016; 34: 564–75.
33. Ferdowsia H, Saiiarib A, Valizadehc R, Gholamie A. The effect of eight-week aerobic exercise on airway trachea indexes (FEV1, FVC, FEV1.FVC & FEF25-75) and Vo2 max level in overweighed male students of Ahvaz Payam Noor University. Procedia Soc Behav Sci. 2011; 15: 2848–52.
34. Kalili A, Elkins M. Aerobic exercise improves lung function in children with intellectual disability: A randomized trial. Aust J Physiother. 2009; 55: 171-5.

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